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RD 54
TASK 5
PHASE I
PROGRESS REPORT #2 - MODEL C

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10 FEBRUARY 1956

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TASK 5
PHASE I
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OBJECTIVE:

To study and evaluate factors and components involved in the design of a miniature infrared voice communicator. To plan and schedule the complete task 5 for the production of Model C equipment.

DATA:

Scheduling.

Delays in the construction of the breadboard optical unit prevented holding the study phase conference as originally planned during the week of 23 January. Instead, it was held on 8 February.

Technical Study.

1. General:

The parts for the breadboard optical unit were completed and assembled. In operation tests in the laboratory dark tunnel the unit has performed very satisfactorily when used with a Model B equipment. The push-to-talk switch for controlling the transmitter lamp was found to be convenient and of definite value in lengthening battery life.

While the value of simultaneous operation of the receiver and transmitter during "find" is evident from theory, there may be some field conditions in which the backscatter from the transmitter would interfere with reception. The equipment has not yet been taken into the field to evaluate these effects.

2. Range Tests:

A series of range tests were made using the laboratory dark tunnel and the vacuum range optical attenuator. The breadboard receiver and transmitter optics were 1-1/2" diameter, 1-1/2" focal length systems similar to those used in the Model D equipment. However, each was equipped with a 1" square aperture mask to simulate the optics proposed for this equipment. Both apertures were fitted with Jena type UG-8 filters of 2 mm thickness.

A Kodak Ektron lead sulfide cell of 1 mm square size and a 3/4 watt lamp were used.

In tests made with a Model B equipment a vacuum range of about three land miles was attained. This would indicate an average clear weather (ACW) range of about two miles. Since the mirror in the repaired Model B prototype used in these tests was not up to production standards of quality, further tests will be made with another mirror. It is expected that even better results will then be obtained.

Tests of the Model C breadboard transmitter operating to the Model C breadboard receiver indicated a vacuum range of about 1-1/4 miles which would give an ACW range of about one mile.

3. Optical System:

a. Lenses.

The results of the breadboard range tests confirm our original predictions that 1" square apertures would be more than adequate to achieve the specified minimum ranges. The use of a square aperture was planned because of the greater modulation linearity as compared with a round aperture. However, since under normal modulation the signal applied to the galvanometer undergoes considerable clipping to increase the average modulation percentage and to protect the galvanometer, the question of minor additional distortion introduced by the modulation system may not be important. The effect of harmonic distortion in the transmitted signal is minimized by the limited high frequency response of the galvanometer itself as well as the characteristic of the lead sulfide receiving cell.

To determine the effect of a square transmitter aperture on overall system voice quality several listening tests were performed in which both round and square apertures were used. Preliminary tests indicate a relatively slight difference in quality but further listening tests as well as quantitative distortion measurements will be made.

If no significant improvement is obtainable with the square aperture, round lenses will be used and the mechanical fabrication problem will be greatly simplified. Otherwise square lenses and mounts would be required or round lenses and mounts with a square mask and its attendant loss in aperture area.

The final choice of lens diameter will be made after the lens shape has been decided. As large an aperture as possible, within the basic size limitations, will be chosen. If a slight increase in case thickness above the basic 1-1/2" dimension is required for the lenses, the case can be flared out slightly at that point.

b. Galvanometer and magnet.

Midwestern Instruments said they believe their Model 102 galvanometer can be modified to meet our requirements. Their estimates predict a sensitivity of 12 ma./inch at a 12" optical arm. The coil resistance is estimated at 30 ohms. The maximum safe continuous current would be 100 ma. while a current of 170 ma. would be safe for a few seconds or less.

With an f1-1/8 system a peak angular deflection of about 12 degrees is required; this corresponds to a 5.3 inch deflection at a 12" optical arm. Thus, for the predicted sensitivity a peak current of 64 ma. (5.3 in. x 12 ma./in.) would be required. With a 30 ohm coil this corresponds to about 62 mw average power requirement for 100 per cent modulation. A power of greater than 300 mw would be required to exceed the maximum safe current of the galvanometer. A modulator designed to produce 75 mw of power and capable of at the most perhaps 125 mw would require no fuse in the output circuit for galvanometer protection.

Some details as to the exact mechanical configuration of the galvanometer must be settled and then a definite order can be placed. Midwestern Instruments' quotation specifies a fixed $300 charge for design modifications and a unit price of $120.

Preliminary work has been done on the magnet and pole piece design and sample quantities of magnets have been ordered for testing.

c. Modulation indicator.

A neon bulb type modulation indicator, operated from the modulation amplifier output, is impractical as: (1) the available audio voltage is not sufficient to strike a glow, and (2) the neon bulb would waste too much power even if sufficient voltage were available. Instead, a system will be used in which a small portion of the visible modulated light from the galvanometer is displayed at a small indicator window to provide an indication of modulation depth. A simple mechanical shutter will provide for dimming and complete shut-off of the visible light.

A modulation indicator of this type has the additional advantage of showing actual modulation of the light and therefore serves to check the galvanometer operation. It would indicate the condition of the lamp and, indirectly, the batteries by judging the brightness of the light.

d. Lamp.

Sample lamps of about 1/2 watt and 3/4 watt sizes have been obtained and tested. As mentioned in section 2, the reported ranges were obtained with the 3/4 watt lamp. Tests were made with a 1/2 watt lamp show a signal reduction of about 3 db as compared to the 3/4 watt. The lower power lamp has essentially the same filament size and therefore operates at a lower brightness. At this time the 3/4 watt lamp appears to be a good choice in view of range and battery life requirements.

e. Cell.

The range tests discussed in section 2 were made using a Kodak Ektron 1 x 1 mm lead sulfide cell. This is the same as those used in the Model B equipments. It appears to be entirely satisfactory and no change is contemplated.

f. Sights.

Open sights are recommended because of their simplicity and small size. At night they would be superior to a small telescopic sight of necessarily limited light gathering ability. A dot of luminous material can be provided on the front sight for night use.

4. Amplifiers:

a. Receiver.

A three stage transformer coupled amplifier has been built in breadboard form. A 2N133 low noise type transistor in the first stage has enabled the noise referred to the input to be reduced to about 3 microvolts. The overall amplifier voltage gain is in the order of 80 db. Temperature stabilization is being investigated and at present the change in gain over the temperature range of $0^{\circ}C$ to $50^{\circ}C$ appears to be satisfactorily small. Power requirements for the amplifier are 4.5 to 5.5 volts at about 3 ma.

b. Modulator.

There has been no further development of the modulator amplifier during this period but additional components for test have been ordered and received.

5. Batteries:

Two general types of batteries are required. One 15 volt battery is needed for cell bias supply and four 1.2 to 1.5 volt cells are required for the amplifiers and lamp. For the cell bias, a battery such as the Burgess Y10 or the Eveready 404E will be used. This battery size is about 5/8" x 5/8" x 1-3/8" and weighs 1/2 ounce. At the normal cell current drain of 20 microamperes the battery life at 70°F would exceed 3000 hours.

For the low voltage cells several types have been considered and tested. A 3/4 watt lamp was used as a load across two series connected cells under test. A very low frequency transistor multivibrator was built to form a test circuit for turning the load "on" and "off" in about 45 second intervals. All tests were made at room temperature.

Mallory RM12R mercury cells gave two hour discharge periods (to 1.9 V endpoint) for two successive days and a one hour period the third day.

Samples of Gould Multi-Lite nickel cadmium storage cells of AA size were purchased. Two of these were tested with the same test setup as above. They gave two hours operation the first day and about 15 minutes the second, before recharging was required. Normally a 10 to 12 hour charge period at an 80 ma. rate is required. When charged at this rate the cell can be overcharged indefinitely without harm, thus allowing the use of a very simple charger. Although the manufacturer has not obtained enough data at this time to state the ultimate life of the AA size cells they state that the D size cell is good for approximately 250 charge-discharge cycles. The cells are hermetically sealed, thus preventing electrolyte leakage problems.

Eveready size AA dry cells were tested under similar load conditions and 30 minutes of operation were obtained the first day, 20 minutes the second, and 10 minutes the third. Thus, although giving very limited service life, they might be useful if other types were not available.

Since all three of these battery types are in the same general size range, it is thought advisable to arrange the mounting and contact clips in the equipment to accommodate all types so that any available type may be used. The low voltage power requirements of the equipment will be met with four cells connected in series. The series will be tapped at two cells to provide power to the lamp at 300 to 350 ma while the amplifier will be connected across the entire series and only require about 15 ma. Thus, when the two cells powering the lamp are down they may be interchanged with the other two which would still be near full capacity. A useful increase in battery service can be obtained in this way.

6. Mechanical Considerations:

It appears at this time that the basic case dimensions of 6" x 4-1/2" x 1-1/2" can be maintained. However, at certain points these dimensions will be exceeded by various projecting parts. Thus the open sights will increase the 4-1/2" dimension slightly at two points. Probably the lenses will increase the 1-1/2" dimension slightly where the case may be flared out. The lenses at the front or the control knobs at the back may increase the 6" dimension somewhat. Efforts will be made to hold such increases to a minimum however.

Estimates of the equipment weight indicate that it will be in the neighborhood of 2-1/4 lb. Of this amount, about .7 lb. is allowed for the case, chassis, etc.; .4 lb. for the batteries; and 1.1 lb. for optical system and electronics.

A Rowi (Germany) no. 76 camera clamp has been obtained for study. Its general features make it fairly good as an accessory clamp for mounting the equipment. However, the clamp jaw opening of 1-1/8" is too small for many applications. An opening of 1-1/2" would be more useful. Other clamps will be studied to determine if a somewhat more versatile clamp is available.

PROGRAM FOR NEXT INTERVAL:

Additional vacuum range tests will be made with the breadboard Model C and the Model B equipped with a different mirror. If possible, some field tests will be conducted as well. Further tests will be performed to determine the effects of aperture shape on overall system distortion and on the basis of these tests a decision will be made regarding lens shape. It will then be possible to determine definite lens specifications and place an order for their design and fabrication.

The order for the galvanometer modulators will be placed as soon as the final details of mechanical design are settled. Further work on the magnet and pole piece assembly design will be done.

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It is expected that the receiver amplifier circuit development will be completed and work will start on the modulator circuit development.

Preliminary mechanical design can proceed as the questions regarding lens size and shape and magnet design are resolved.

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Report approved by:

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